The LVSR Rear Body Unit (RBU) Flatrack Analysis

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14. ABSTRACT
The purpose of this study was to discuss the results of the analysis used in developing a standard flatrack capability for the existing Logistics Vehicle System (LVS) Rear Body Unit (RBUs) while maintaining or improving the current capabilities. DDL Omni wanted to determine if it was feasible to take the capabilities of three RBU's (MK15, MK16, and MK17) and mount them on a flatrack that could be picked up by the MK18A1. This would eliminate four dedicated RBU's (if one considers replacing the MK14 with the MK18A1 and a flatrack), while allowing the flexibility of one vehicle performing all of the LVS capabilities. DDL Omni evaluated the pros and cons of each flatrack designs, and provided cost comparisons for new designs versus the existing RBU's.

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EXECUTIVE SUMMARY

DDL OMNI was tasked to study the capabilities of three LVS rear body units (RBU) to determine if the capabilities of each RBU might be mounted on a flatrack, and then employed by the MK48/MK18A1. The LVS RBUs analyzed were the MK15 wrecker recovery variant, the MK16 fifth wheel variant and the MK17 dropside cargo variant, with crane. The use of a mission configured flatrack could eliminate four dedicated RBUs (if one considers replacing the MK14 with a MK18 and a flatrack), while allowing the flexibility of one vehicle performing all of the LVS capabilities. We began by developing preliminary designs for each flatrack and finally performing an engineering analysis to determine if the flatrack design could meet or exceed the capability of the RBU it would replace. In the course of our research, we found that numerous Marine Corps studies, analyses and wargames, highlighted serious deficiencies in bulk liquid transportation/distribution. We performed an engineering analysis to determine how much bulk fuel (JP8/diesel) or bulk water could be transported given the various LVSR off road payload capabilities. In summary therefore, our analysis showed:

MK15 Wrecker/Recovery: The MK15 wrecker/recovery RBU is used primarily to lift and tow fully loaded LVS from the front or rear. It is also capable of lifting and towing the HMMWV, and the Medium Tactical Vehicle. A heavy duty rear winch enables the wrecker to free mired vehicles. The wrecker is equipped with a material handling crane, and an auxiliary hydraulic circuit providing power for tools used by the vehicle operator. The MK15 Wrecker/Recovery capability can be mounted on a flatrack design due to the ease of mounting the current components and the limited dimensional requirements.

Because the current "A" frame lifting unit has operational limitations, we identified a commercially available underlift design that can be adapted to a RBU frame, or to a flatrack. This underlift is called the T-50 and is available through a commercial vendor.

In general though, a flatrack wrecker is not recommended because of the forces encountered by lifting and towing vehicles weighing up to 45 tons, and the attachment points for the flatrack. Our analysis indicated user difficulty in operating the existing A-frame lifting unit, so we recommend replacing that system with a recovery capability similar to the T-50 commercial underlift system available from Miller Industries. Based on this information a dedicated RBU is recommended for the MK15 Wrecker/Recovery Vehicle. The incorporation of the T-50 underlift system to either the dedicated RBU or flatrack would require modifications to the chassis of the MK18A1. The dedicated RBU and the flatrack design would require relocation of the winch and crane to allow ample space for stowage of the T-50 underlift system. Both designs would increase the current length of the RBU due to the stowage of the new T-50 underlift system however, the T-50 could possibly be modified to stay within current dimensions.

MK15 Dedicated / Flatrack RBU Cost Analysis: The flatrack wrecker/recovery variant is not recommended, but, it may be feasible to implement the T-50 underlift system on the dedicated RBU. The cost of installing a T-50 underlift system is approximately $60,000.

MK16 Fifth Wheel Semi-trailer Adapter : The MK16 is used to haul semi-trailers with 3.5 inch diameter kingpins. Its primary mission is to haul the M870 and M1000 semi-trailers. A rear winch mounted in front of the fifth wheel is capable of pulling a combat loaded main battle tank onto a semi-trailer without using the tank's own power.

The MK16 Fifth Wheel Truck Tractor is not a recommended candidate for replacement using a flatrack design because the fifth wheel would be too high for the M870 or M1000 semi-trailer. Also, the flatrack design increases the length of the current RBU and may cause turning radius problems. Lowering the height of the flatrack mounted fifth wheel would require major modifications to the MK18A1 suspension and M1077 flatrack. In addition to the height and length problems, mounting point stresses of the flatrack while handling a load on the 5th wheel may pose a problem at the attachment points. Accordingly, we recommend the MK16 remain a dedicated RBU.

MK16 Dedicated / Flatrack RBU Cost Analysis: An analysis was performed to determine a cost increase/decrease for using a flatrack mounted RBU. The dedicated RBU prices were based on the LVASA1 contract signed in FY95. Additionally, some costs were estimated and some obtained from Haystack. The cost analysis indicated that the flatrack/MK18A1 fifth wheel RBU would cost approximately $60,000 more than a dedicated rear body unit with the same capabilities.

MK17 Dropside Cargo, With Crane: The MK17 is used to transport palletized and dimensionally standard cargo in ISO containers. The side panels on the cargo bed can be dropped down or removed to ease loading and unloading activities. The side panels also provide seating for troops. A material handling crane at the rear of the vehicle is used to load and unload cargo and equipment.

The current MK17 dropside cargo, with crane is an excellent candidate for replacement using a flatrack design due mainly to the simplicity of the current dedicated RBU. The vehicle length remains virtually the same when using the MK18A1 with a flatrack in place of the existing MK17. The crane can be mounted at the front or rear of the flatrack. The payload may be diminished some due to the 3000 lb weight of the flatrack itself. Current flatracks have a capacity of 16.5 tons which may be a problem with the higher LVSR payloads. The suspension of the MK18A1 would have to be enhanced to account for the additional weight of the flatrack.

MK17 Dedicated / Flatrack RBU Cost Analysis: An analysis was performed to determine a cost increase/decrease for using a flatrack mounted RBU. The dedicated RBU prices were based on the LVASA1 contract signed in FY95. Additionally, some costs were estimated and some obtained from Haystack. The cost analysis indicated that the flatrack/MK18A1 dropside cargo RBU would cost approximately $15,000 more than a dedicated rear body unit with the same capabilities.

Bulk Liquid Flatracks: The Marine Corps has a serious deficiency in delivering large quantities of bulk liquids. Currently, bulk water and fuel are delivered using the SIXCON tank and pump modules. These modules are highly inefficient because of their unfavorable payload to tare ratio. We did an engineering analysis of the US Army's 3000 gallon fuel tank mounted, on a flatrack, and an analysis of a commercial fuel tank (Hapaag-Lloyd) with a higher tare weight, to determine the number of gallons the LVSR could haul given off road payload capacities of 12.5 tons, 16.5 tons, and 22.5 tons. We investigated dedicated RBUs and a tank design that is incorporated into a flatrack that could be loaded and unloaded by the MK18A1. The tank would have the capability of pumping 250 gpm from two hoses. Each hose would be 50 feet long.

DDL OMNI's analysis indicates from a design point of view that both the dedicated fuel / water RBU and a flatrack mounted fuel / water tank are feasible. The one disadvantage of having a flatrack mounted RBU is the 3000 lb penalty paid for the weight of the flatrack causing less fuel and or water to be carried as compared to the dedicated RBU. An important finding is that given an offroad payload of 22.5 tons for the LVSR, fuel and water tanks in the 5000 gallon range are feasible. This could replace some of the aging M970 refueler semi-trailers in the USMC inventory. An advantage of the flatrack design is that, it allows for other missions and functions to be performed by the MK18A1 system after you drop off the flatrack where as the dedicated unit does not.

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1.0 INTRODUCTION

1.1 Background:

In the future, the Marine Corps will be operating "Forward From the Sea" in the littorals in concert with the US Navy. "Forward From the Sea" has generated the Marine Corps "Operational Maneuver From The Sea" and "Ship to Objective Maneuver" concepts that are shaping future requirements at the strategic, operational and tactical levels.

Marine Corps requirements for transportation units supporting MAGTF forces ashore operating in the littorals, will shape the capabilities and characteristics of the LVSR rear body variants. The capabilities and characteristics will be determined by examining the mission, threat and the operational scenario. The amount and type of cargo being transported, where its coming from, and where it will be delivered will determine the specific rear body capability.

Based on guidance from MARCORSYSCOM, we began our RBU design by looking into a standard RBU that would be able to lift/load different mission specific modules mounted on a pallet or flatrack. Since the MK18A1 is similar in design to the US Army Palletized Loading System, it is assumed that this type of lifting capability will be the lift capability of choice for the LVSR.

1.2 Purpose of Task:

The purpose of this report is to discuss the results of our investigation into developing a standard flatrack capability for the existing LVS RBU's while maintaining or improving the current capabilities. DDL OMNI wanted to determine if it was feasible to replace current rear body units with the MK18A1 with a series of flatracks similar capabilities. AutoCad was used to develop the concepts. DDL OMNI evaluated the pro's and con's of

each flatrack design, and provided cost comparisons for new designs versus the existing RBU's. DDL OMNI has provided recommendations for the feasibility of the flatrack designs to replace the current RBU's.

During our analysis of RBU capabilities, we were asked to develop preliminary concepts for a new dedicated fuel and water rear body unit and palletized fuel and water mission module(s). Capacities varied based on the 12.5 ton, 16.5 ton, and 22.5 ton off road capability that is currently being investigated. The U.S. Army's Palletized Load System (PLS) Total Distribution system was used as a benchmark for this investigation.

2.0 PRE-ANALYSIS PHASE

2.1 Current Capabilities:

DDL OMNI began by examining the current RBU's capabilities. The following is a list of those capabilities:

MK48/15 Wrecker / Recovery Vehicle

- 11 ft Steel Cargo body with for/aft storage compartments
- 9,000 lb Material Handling Crane
- 60,000 lb Recovery Winch
- Tow Loading: 32,000 lb
- Payload: 10 ton
- Lift and Tow fully loaded LVS, MTVR and HMMWV from front and rear
- Capable of towing LAV

MK48/16 5th Wheel Truck Tractor

- Tows the M870 40 ton low bed semi-trailer and the M1000 Heavy Equipment Transporter
- Fully oscillating 5th wheel for 3.5" kingpin
- 60,000 lb Recovery Winch
- 5th Wheel Loading: 46,000 lb

MK48/17 Dropside Cargo Truck

- 16 ft Steel cargo body with drop sides, troop seats and cargo cover
- 9,000 lb Material Handling Crane
- Payload: 10 ton off-road, 19.5 ton on-road

MK48/18 ISO Container/Ribbon Bridge/Boat Hauler

- Able to transport 20 ft ISO container, Payloads up to 45,000 lb
- Able to transport ribbon bridges
- Able to transport Boat Hauler

2.2 Government / Commercial Programs:

DDL OMNI gathered and analyzed information that we felt would be pertinent to the feasibility study. We examined the current PLS Total Distribution System and the M1077 Flatrack (payload capacity 16.5 tons) that is associated with this system because the current MK18A1 employs a similar system. The current PLS system has a hydraulically powered arm with a hook that lifts the flatrack on or off the rear body. Our investigation uses the M1077 flatrack shown in Figure 1 as the foundation for the flatrack RBU's. Modifications to the flatrack may be necessary and are indicated in the report.

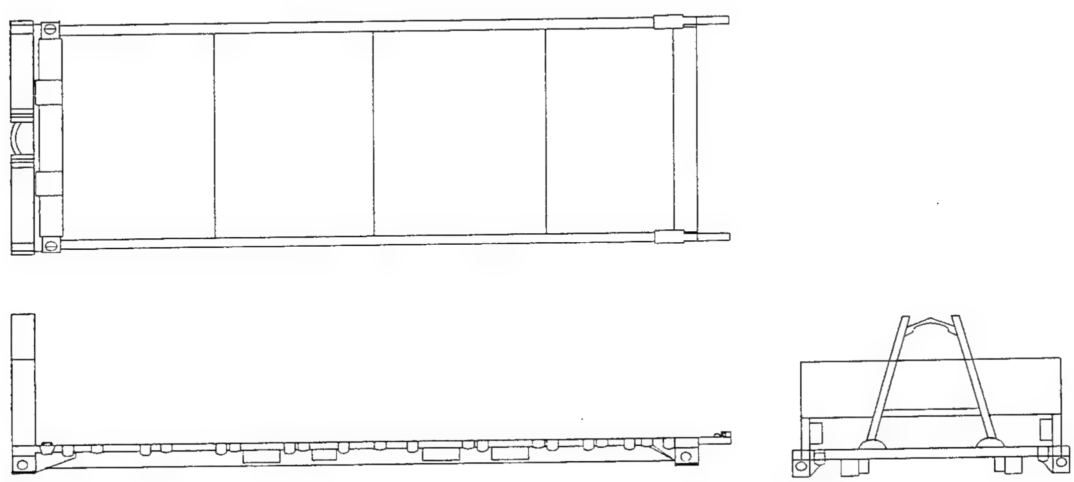

Figure 1.0 M1077 Flatrack

We also reviewed the following programs that may impact our investigation such as data on the HEMMT M977 Series Truck; the Boughton Military Pallet Loading System

(DROPS/PLS); the PLS Alternative Use 3000 gallon Fuel Tank and Pump Module as well as the 3000 gallon Bulk Water Transport and Pump Module, Atlas Polar's Multilift Quick Change Body Systems as well as the Moxy Truck MT30 LHS. DDL also contacted Tampa Tank, Inc. an industry leader in the design and manufacturing of tank systems, to obtain their expertise on tank design. Another commercial company that provided us with valuable information concerning the Recovery/Wrecker RBU was Miller Industries. Miller Industries is the global leader in state of the art vehicle recovery systems used commercially throughout the United States.

3.0 RBU / Flatrack Investigation

3.1 MK48/15 - Wrecker/Recovery Vehicle

Before proceeding with the MK15 analysis we met with the user to determine if there were any current shortfalls with the existing system. The user indicated that the existing A-Frame lifting unit system is difficult to use. Based on this information DDL OMNI examined commercially available, state of the art recovery systems that may be adaptable for use on the LVSR to replace the current system and provide current if not better capability both on and off road. Our analysis was based on an underlift system.

Initially, it would appear that the current MK15 Wrecker/Recovery vehicle shown in Figure 2.0 would be a good candidate for replacement by a flatrack. All current

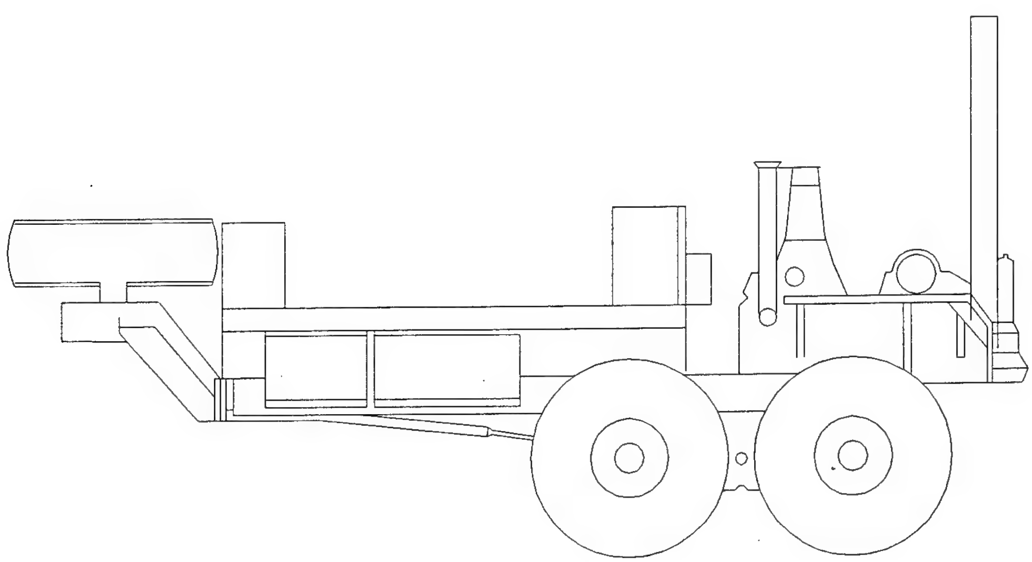

Figure 2.0 MK15 Wrecker/Recovery Vehicle

capabilities could be mounted on the flatrack and it would be very easy to load and employ using a MK18A1. However, because the current "A" frame lifting capability has been regarded as unsatisfactory, we investigated mounting a commercial underlift design. Here is where we ran into problems with the flatrack.

The MK15 main components consist of an 11 ft steel cargo body with for/aft storage compartments, 135,000 ft lb crane and a rear mounted 60,000 lb recovery winch for assisting disabled vehicles. Taking these components, excluding the A-frame which will be replaced by an underlift system and mounting them on a flatrack would require design modifications to the frame and flatrack. Problems may also arise when we attempt to attach the flatrack to the frame. Since the MK18A1 system attaches at only four points the forces endured by these locations while using the underlift system may pose a problem.

The mounting of the state of the art underlift recovery system poses the largest challenge. To gain insight into the difficulties we may encounter with underlift systems, DDL OMNI met with Capitol Truck Corporation and WIL-BAR Truck Inc. who are both distributors of Miller Industries wrecker recovery systems under the brand names of Century and Challenger just to name a few. Eventually, we met with representatives of Miller Industries to discuss how the current state of the art recovery systems may be adapted to the existing LVS RBU or how the system could be implemented on a flatrack such as the M1077 and what problems we may encounter.

DDL OMNI provided representatives from Miller Industries and Capitol Truck Corporation with drawings and pictures of the existing MK15 and the M1077 Flatrack. We explained to them the current capability of the recovery system to see if they had a system that would provide the same if not improved capability and if it was feasible to mount it to a flatrack or a dedicated RBU. Based on our requirements, Miller representatives recommended the T-50 underlift system as a viable candidate for the dedicated RBU and possibly the flatrack. Please see the enclosed brochure on the T-50 underlift system in Appendix A of this report. Miller could not provide us with detailed

designs but indicated it would be feasible to use an underlift system for the dedicated RBU and flatrack. They informed us that the mounting location for the T-50 and storage location may cause some difficulty.

A response to the NSWC, Carderock BAA was submitted to investigate this task further. DDL OMNI teamed with Miller Industries who committed to providing us with a detailed implementation of the T-50 underlift system on the current MK15 and the M1077 Flatrack.

The investigation indicated various pro's and con's for a flatrack and a dedicated RBU for the Wrecker/Recovery vehicle. That information and recommendation based on the feasibility study is as follows:

3.2 Pro's and Con's

3.2.1 Flatrack

Pros:

- A-Frame is complex and time consuming to operate on current system
- Allows for family of Flatracks and one common chassis (MK18A1)

Cons:

- Risk involved in locating underlift system (storage) and weight/load management on existing RBU
- Modifications necessary to Flatrack and chassis may offset T-50 underlift capability
- Attaching underlift to chassis negates flexibility of the flatrack
- Current T-50 stowage location extends existing length of RBU
- Incorporation of underlift system will cause existing crane and winch locations to change

3.2.2 Dedicated RBU

Pros:

- State of the art commercial recovery equipment (T-50 underlift system by Century) adaptable to LVS
- Underlift does away with A-Frame that is complex and time consuming to operate on current system
- Cost effective

Cons:

- Risk involved in locating underlift system (storage) and weight/load management on existing RBU
- Modifications necessary to Flatrack and chassis may offset full T-50 underlift capability
- Current T-50 stowage location could extend length of RBU beyond MK15
- Incorporation of underlift system will cause crane and winch existing locations to change
- Eliminates ability to have a family of Flatracks and one common chassis

3.3 MK15 Dedicated RBU vs. MK15 Flatrack RBU Cost Analysis

DDL OMNI performed a cost analysis to determine the cost effects of using a Flatrack design for the RBU as compared to the existing dedicated RBU's. Production prices were based on the LVSA1 contract signed FY95. Some costs were estimated and others were obtained from HAYSTACK.

3.3.1 Cost Analysis

MK15A1 Wrecker / Recovery Vehicle		$ 205,342*
vs.		
Flatrack w/ MK18A1		
MK18A1 Container Hauler		$ 115,800*
M1077 Flatrack		$ 6,873**
Material Handling Crane (est.)		$ 25,000
DP Winch (60,000 lb) (est.)		$ 16,000
A-Frame (32,000 lb) (est.)		$ 20,000
T-50 Underlift System		$ 60,000***
	Total:	$ 243,673

Pricing:

* Production prices provided by MARCORSYSCOM based on the LVSA1 contract signed FY95.

** Haystack

*** Miller Industries

3.3.2 Results

- Cost data indicates a $38K increase using the Flatrack w/ MK18A1 for the MK15 Wrecker Recovery RBU although the flatrack has added capability with the T-50 Underlift system (ease of operation, state of the art).

3.4 Recommendation:

A dedicated RBU is recommended for the LVSR Wrecker/Recovery Vehicle. First, major modifications would be required to incorporate the T-50 underlift system on the M1077 flatrack. Secondly, the ability to unload and load the flatrack with the T-50 underlift

system involves high risk and may not be able to be done. The flatrack wrecker is also not recommended because of the mounting point stresses encountered by the flatrack while lifting and towing vehicles weighing up to 45 tons. This may require that new attachment points be added which negates the use of a flatrack. Finally, the cost to use a flatrack is approximately $38K more than using a dedicated RBU as determined in our analysis.

Miller Industries would participate in an effort to streamline the design for stowing the T-50 with the least implications to the necessary capability requirements. To employ the flatrack, modifications such as cutting away some of the flatrack to allow proper storage of the T-50 underlift system is necessary contributing to the flatrack being a non-viable solution.

The following two figures, Figure 3.0 MK15 Dedicated Wrecker/Recovery Vehicle and Figure 4.0 MK15 Wrecker/Recovery Vehicle with Flatrack depict the preliminary designs that were created in AutoCad and evaluated during the RBU/Flatrack analysis.

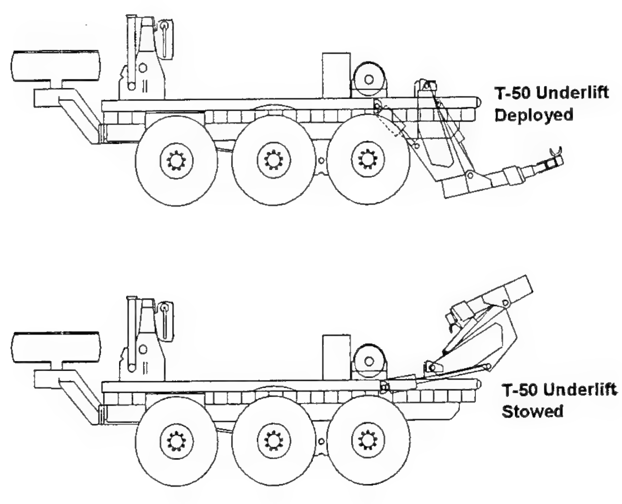

Figure 3.0 MK15 Dedicated Wrecker/Recovery Vehicle

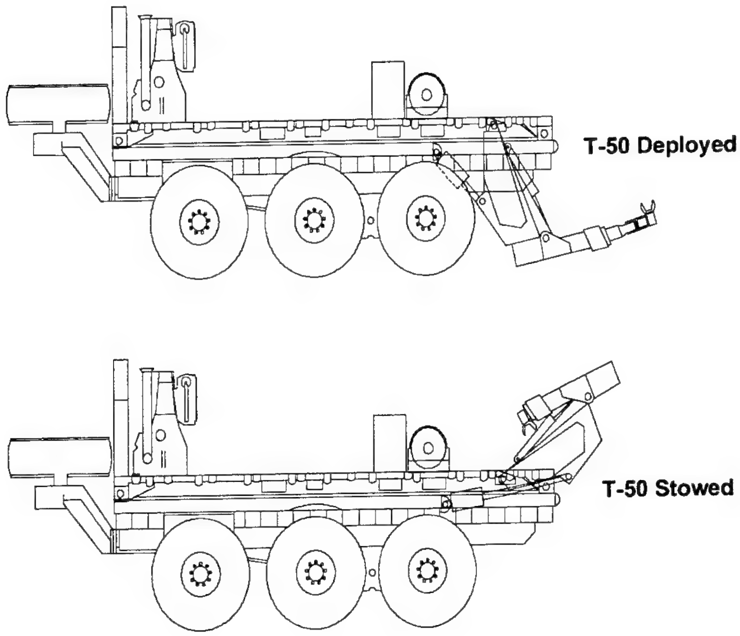

Figure 4.0 MK15 Wrecker/Recovery Vehicle with Flatrack

Although Miller Industries provided us with limited information concerning the necessary mounting points and stowage capability of the T-50 underlift system we were still able to make preliminary designs that were the basis for our evaluations.

Please see Figure 5.0 Commercial Wrecker Recovey Vehicle Systems and the attached Miller Industries Challenger T-50 underlift system brochure in Appendix A for additional information.

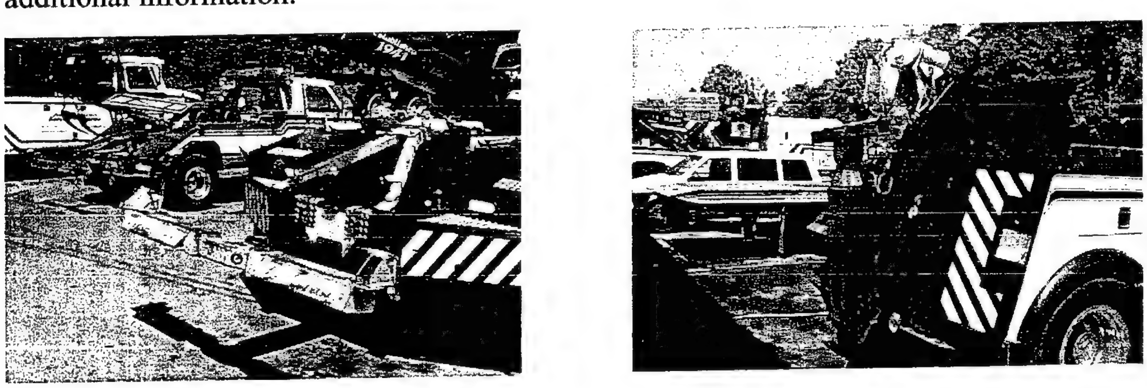

Figure 5.0 Commercial Wrecker Recovery Vehicle Systems

3.5 MK48/16 - 5th Wheel Truck Tractor

The MK16 main components consist of a fully oscillating 5th wheel accepting a 3.5" kingpin with a 5th wheel loading of 46,000 lb, and a 60,000 lb recovery winch, which enables the MK16 operator to recover disabled vehicles by winching them on to the towed semi-trailer. The MK16 tows the M1000 and M870A1 semi-trailers. Taking these components and mounting them on a flatrack would require changes to the existing flatrack. Using the flatrack as currently designed and stowed on the MK18A1 will not allow for proper height positioning of the 5th wheel. The current MK16 is shown in Figure 6.0.

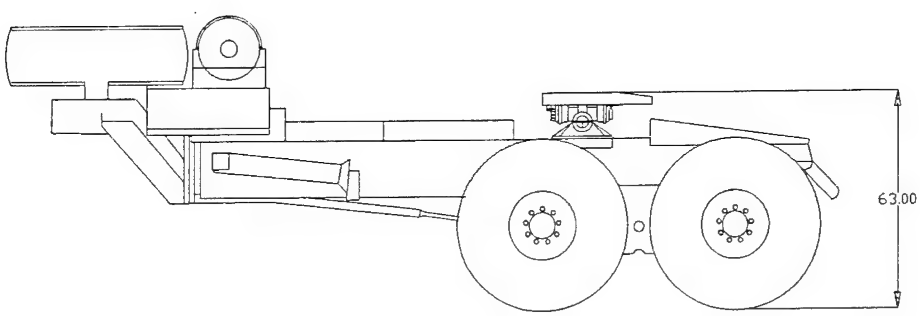

Figure 6.0 MK16 5th Wheel Truck/Tractor

DDL OMNI contacted Atlas Polar's Multilift Quick Change Body Systems in Ontario, Canada who has developed a 5th wheel rack system, mounted on rails, that allows for proper adjustment of the 5th wheel both horizontally and vertically. Although detailed information on their design was not provided, we were able to ascertain that there is a

feasible design available, however, modifications to the flat rack would be extensive and therefore carry with it a high degree of risk.

Figure 7.0, MK16 5th Wheel Truck Tractor with Flatrack, depicts the preliminary design that was created in AutoCad and used to evaluate the MK16 RBU/Flatrack.

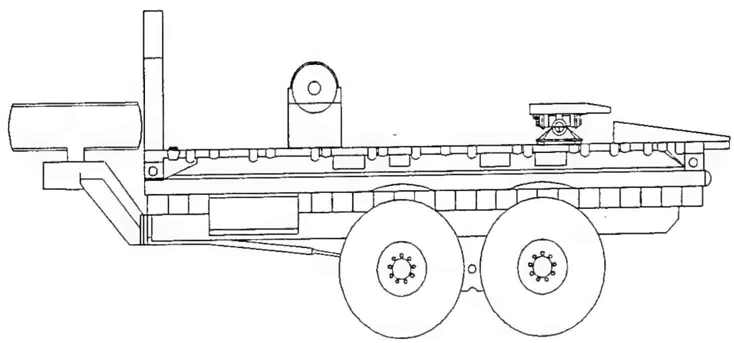

Figure 7.0 MK16 5th Wheel Truck Tractor with Flatrack

As discussed earlier, DDL OMNI was in contact with Atlas Polar Company Limited based in Toronto, Canada that produces the Multilift Quick Change Body Systems that range in capacities from 3 to 22 tons. Atlas has designed a 5th wheel flatrack system. As indicated earlier, their 5th wheel flatrack design was open in the middle with rails that allowed the 5th wheel to adjust to pre-determined height and horizontal mounting locations as required.

3.6 Pro's and Con's

3.6.1 Flatrack
Pros:

- Allows for a family of Flatracks and one common chassis (MK18A1)
- Commercial designs are available from multiple sources

Cons:

- Current RBU is approximately 5 ft shorter in length than the MK18A1
- Proper vertical positioning of 63" for the 5th wheel on the current M1077 Flatrack becomes a challenge
- The increased length may contribute to turning radius problems
- Flatrack without modifications will cause the existing 5th wheel height location of 63" to increase 23"

3.6.2 Dedicated RBU
Pros:

- Allows for proper 63" positioning of the 5th wheel
- Increased length due to flatrack is eliminated
- Turing radius problems due to increased length are eliminated
- Current design (MK16) is adequate

Cons:

- None

3.7 MK16 Dedicated RBU vs. MK16 Flatrack RBU Cost Analysis

DDL OMNI performed a cost analysis to determine the cost effects of using a Flatrack design for the RBU as compared to the existing dedicated RBU's. Production prices are based on the LVSA1 contract signed FY95. Some costs were estimated and others were obtained from HAYSTACK. Following the cost analysis, results are provided.

3.7.1 Cost Analysis

MK16A1 5th Wheel Truck Tractor		$ 88,801*
vs.		
Flatrack w/ MK18A1		
MK18A1 Container Hauler		$ 115,800*
M1077 Flatrack		$ 6,873**
DP Winch (60,000 lb) (est.)		$ 16,000
5th Wheel (est.)		$ 10,000
	Total:	$ 148,673

Pricing:

* Production prices provided by MARCORSYSCOM based on the LVSA1 contract signed FY95.

** Haystack

3.7.2 Results

- Cost data indicates a $60K increase using the Flatrack w/ MK18A1 for the 5th Wheel Truck Tractor although this design is not feasible.

3.8 Recommendation:

The current MK16 5th Wheel Truck Tractor is not a good candidate for replacement using a flatrack design because of the major flatrack and MK18A1 modifications required to meet the 63" 5th wheel height requirement. Also, the flatrack design increases the length of the current RBU and may cause turning radius problems. Additionally, mounting point stresses at the attachment points of the flatrack while handling the 43,000 lb 5th wheel load may require that additional attachment points be added to the flatrack. These additional attachment points increase the number of modifications to the flatrack. Accordingly, a dedicated RBU is recommended for the MK16 5th Wheel Truck Tractor. The 5th Wheel Truck Tractor RBU meets the required length and 5th wheel height.

3.9 MK17 - Dropside Cargo Truck (Breakbulk Cargo / Troop Hauler)

The current MK17 Dropside Cargo Truck with crane is an excellent candidate for replacement using a flatrack design due to the simplicity of the current dedicated RBU. The MK17's main components consist of a 16 ft steel cargo body with fold down sides and a 9,000 lb material handling crane. The current payload is 10 tons off-road and 19.5 tons on-road. Taking these components and mounting them on a flatrack would require minimal changes to the existing flatrack. The vehicle length remains virtually the same when using the MK18A1 with a flatrack in place of the existing MK17. Although the length remains the same the cargo bed and crane height are increased. This increase in height will raise the center of gravity of the RBU and may cause vehicle stability problems at the proposed new height. This must be examined further to obtain conclusive results. See Figure 8.0 for the MK17 Dropside Cargo Truck.

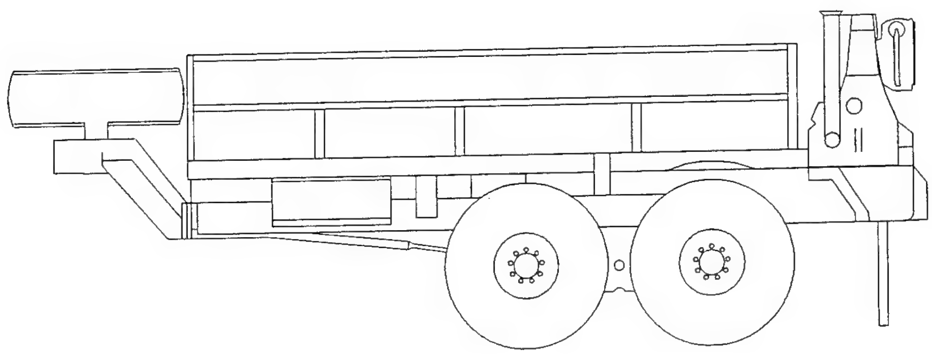

Figure 8.0 MK17 Dropside Cargo Truck

The investigation indicated various pro's and con's for a flatrack and a dedicated RBU for the MK17 Dropside Cargo Truck. That information and a recommendation based on the feasibility study is as follows:

3.10 Pro's and Con's

3.10.1 Flatrack

Pros:

- The current RBU is approximately the same length as the MK18 RBU and should not pose a problem with the flatrack design
- Allows for a family of Flatracks and one common chassis (MK18A1)

Cons:

- Flatrack may erode payload capacity by adding an additional 3000 lb to the weight of the RBU

- Stress at the attachment points must be examined due to increased load
- Height of cargo bed and crane increased, RBU CG rises and may cause stability problems

3.10.2 Dedicated RBU

Pros:

- Lift stress more evenly spaced over frame.

Cons:

- Dedicated unit cannot perform other mission/functions

3.11 MK17 Dedicated RBU vs. MK17 Flatrack RBU Cost Analysis

DDL OMNI performed a cost analysis to determine the cost effects of using a Flatrack design for the RBU as compared to the existing dedicated RBU's. Production prices based on the LVSA1 contract signed FY95. Some costs were estimated and others were obtained from HAYSTACK. Following the cost analysis, results are provided.

3.11.1 Cost Analysis

MK17A1 Dropside Rear Body Unit		$ 134,794*
vs.		
Flatrack w/ MK18A1		
MK18A1 Container Hauler		$ 115,800*
M1077 Flatrack		$ 6,873**
Dropsides (est.)		$ 2,500
Material Handling Crane (est.)		$ 25,000
	Total:	$ 150,173

Pricing:

* Production prices provided by MARCORSYSCOM based on the LVSA1 contract signed FY95.

** Haystack

3.12 Results

- The cost data indicates a $15K increase using the Flatrack w/MK18A1 for the MK17 Dropside Cargo RBU.

3.13 Recommendation:

A flatrack design is recommended for the MK17 Dropside Cargo Truck. Based on our analysis the flatrack design for the MK17 seems to be the most feasible. The vehicle length remains virtually the same when using the MK18A1 and a flatrack in place of the existing MK17. The payload may be diminished some do to the 3000 lb weight of the flatrack itself. The problem may be with the suspension of the MK18A1 that will be carrying the flatrack consisting of the necessary modifications to include the dropside cargo storage and crane. Further, the rise in the height of the cargo bed and crane due to the flatrack may cause instability in the rear body unit. This needs to be investigated further.

The following figure, Figure 9.0 MK17 Dropside Cargo Truck with Flatrack depicts the preliminary design that was created in AutoCad and evaluated during the dedicated RBU/ Flatrack analysis.

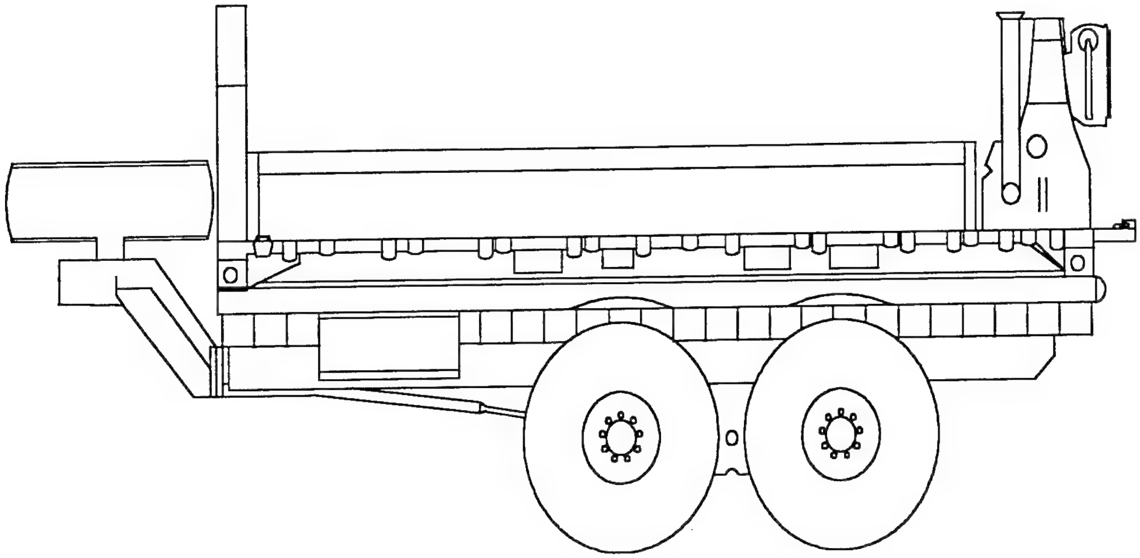

Figure 9.0 MK17 Dropside Cargo Truck with Flatrack

4.0 FUEL/WATER DEDICATED RBU/FLATRACK INVESTIGATION

4.1 Analysis

DDL OMNI performed an analysis to determine the feasibility of making a dedicated RBU or Flatrack that will transport bulk fuel and water. We contacted Haapag Lloyd and the US Army PLS Alternative Use Team which has been examining ISO compatible tankrack applications such as the fully contained, flatrack mounted 3000 gallon fuel tank and pump unit for the PLS. We informed them we were looking at exceeding the 3000 gallon threshold and asked if they could provide us with information on both the 3000 gallon water and 3000 gallon fuel transports. Figure 10.0 depicts the PLS Alternative Use Team 3000 gallon Tankrack design completed in November 1996.

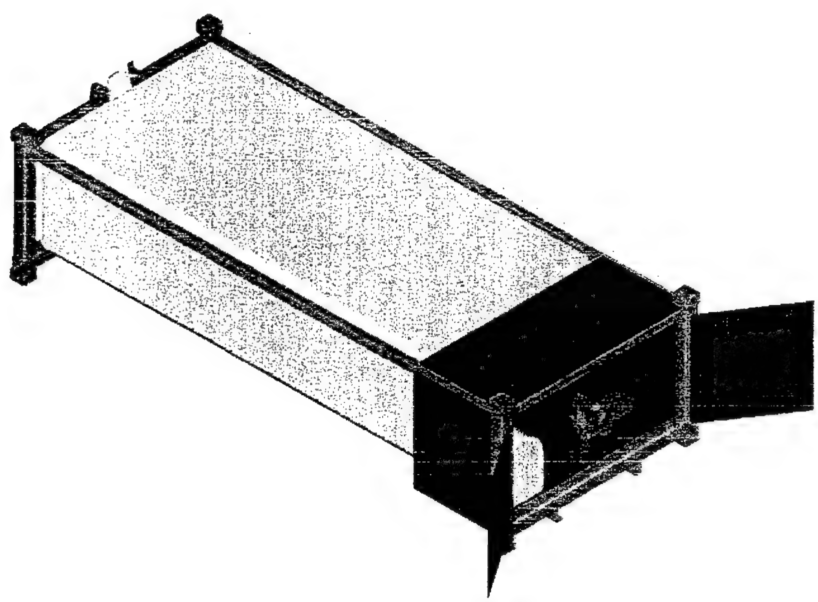

Figure 10.0 PLS Alternative Use Team 3000 gallon Tankrack

The PLS team indicated that the idea for developing these alternative mission modules arose from the volume of comments coming from the field as to the multiple uses for which the user could envision using the PLS, as well as the great success of the English version of the PLS which had been used for a variety of missions during Operation Desert Storm. Also, the Combat Systems Support (CSS) Operational Capabilities Requirements are placing a greater emphasis on the need for tactical CSS units to keep pace with maneuver units, a capability for which the PLS is uniquely suite with its improved mobility. This reasoning can also be applied to the LVS-R. DDL OMNI hoped to develop a design similar to the US Army's fuel tank design. Each system would have the features shown in Table 1.

Table 1.0 Bulk Liquid Tank Features

Features	Automotive / Aircraft Refueling	Water / Drinking Water
Tankrack	Heavy Duty Style	Heavy Duty Style
Compatability	PLS/DROPS	PLS/DROPS
Tank Mounts	Floating	Floating
Capacity	>3000 gal	>3000 gal
Material	Stainless Steel	Stainless Steel
Compartments	One	One
GPM High Flow	250	250
GPM Low Flow	0-60	0-60
Filter/Seperator	Optional	N/A
Meter	One	N/A
Delivery Reels/Hoses	Two	Two
Bypass System	Standard	Standard
Engine	1 Cylinder Diesel	1 Cylinder Diesel
Pump	Centrifugal 3x2	Centrifugal 3x2
Fuels	JP-5, JP-8, Diesel	N/A
Dust Control	N/A	Spray Bar
Faucets	N/A	up to Four
Chiller	N/A	Optional
Heater	N/A	Optional

We concentrated our efforts on determining the size of the tanks we could develop to determine the number of gallons the LVSR could haul given off road payloads of 12.5, 16.5 and 22.5 tons. A spreadsheet was developed to determine and track the size of the tanks that could be used. See Appendix B. Bulk Water and Fuel Tank Sizes. A range of Payload/Tare ratios starting initially with the Happag Lloyd design (2.26) and the current PLS design (6.00) were evaluated. Based on these ranges we were able to determine various bulk liquid capacities of the tanks to support each payload category. The size of the tanks also depended on the area to hold the tank along with a designated area for a pumping unit. This was done for both the flatrack and dedicated RBU designs. Our analysis was driven by a desire to keep the center of gravity as low as possible. The tank sizes generated for each payload, various payload/tare ratios and whether it's for a dedicated RBU or flatrack design are shown in Figure 11.0 LVS-R Water/Fuel RBU without Flatrack and Figure 12.0 LVS-R Water/Fuel RBU with Flatrack. These figures depict the penalty you pay for the additional 3000 lb that the flatrack adds to the payload. For instance, the fuel and water tank designs without the flatrack had maximum capacities of 5022 gallons for water and 6052 gallons for fuel at a payload/tare ratio of 6.00 which was the same as the PLS's design. Basically, the higher the payload/tare ratio the more you can carry per the tank designs own weight.

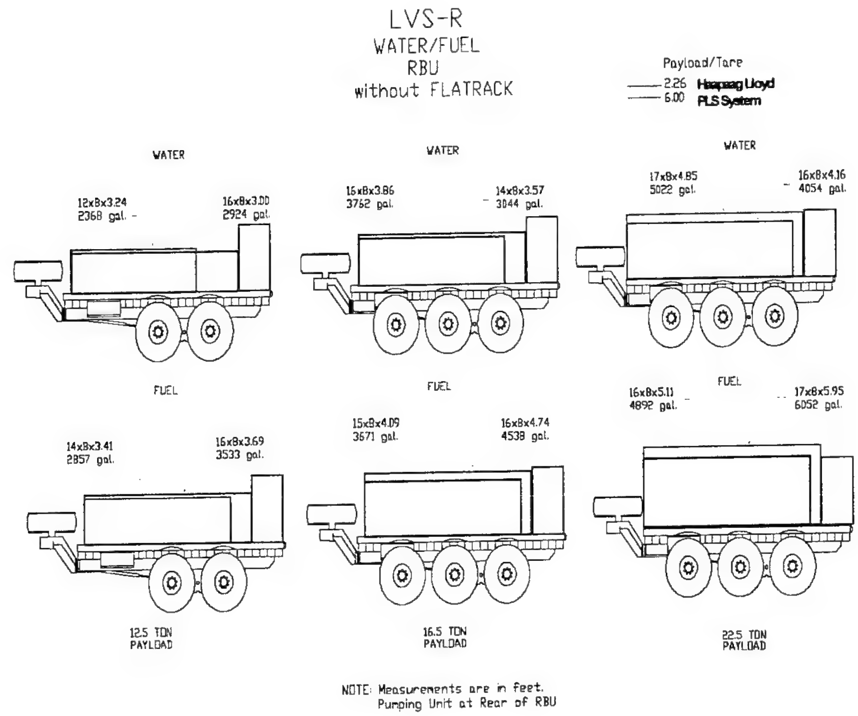

Figure 11.0 LVS-R Water/Fuel RBU without Flatrack

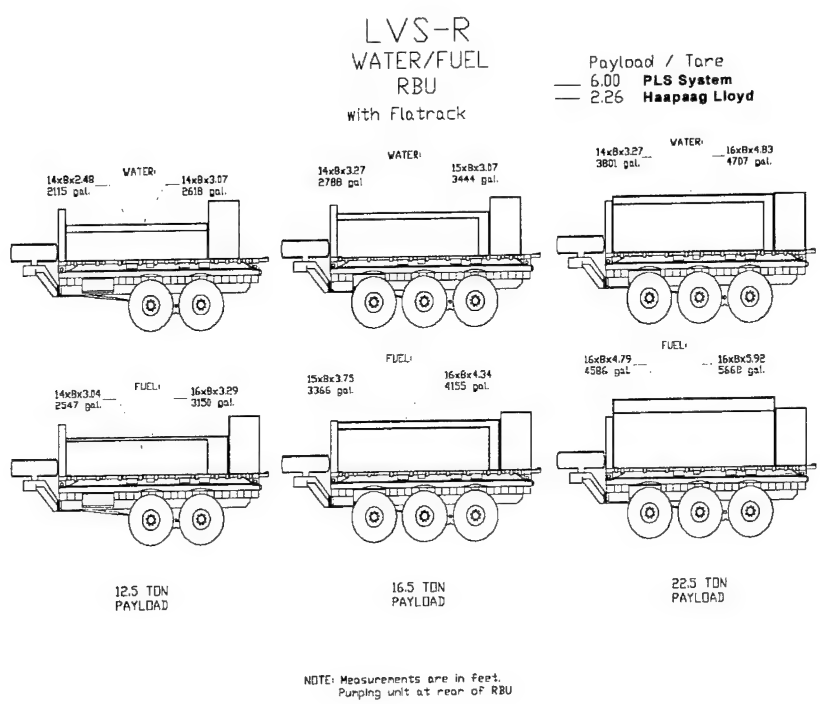

Figure 12.0 LVS-R Water/Fuel RBU with Flatrack

DDL OMNI contacted Tampa Tank, Inc. to determine the feasibility of manufacturing the size tanks that were developed in our analysis. Tampa Tank indicated there wouldn't be a problem manufacturing the tanks to fulfill these payload requirements.

4.2 Recommendations

From a design point of view both the dedicated fuel/water RBU and a flatrack mounted fuel/water tank are feasible. The one disadvantage of having a flatrack mounted RBU is the 3000 lb penalty for the flatrack, which reduces the amount of fuel and or water that can be transported. An important finding is that given an offroad payload of 22.5 tons for the LVS-R, fuel and water tanks in the 5000 gallon range are feasible. This could replace some of the aging M970 refueler semi-trailers in the USMC inventory. An advantage of the flatrack design is that it allows for other missions and functions to be performed by the MK18A1 system after you drop off the flatrack where as the dedicated unit does not. For example, the flatrack module can be delivered to a grid coordinate where combat vehicles will refuel. In this way, one vehicle can deliver to multiple areas. Also, multiple tanks delivered to one area creates, in effect, a mobile fuel farm.

A response to the NSWC, Carderock BAA was submitted to investigate this task further. DDL OMNI teamed with Tampa Tank, Inc. to pursue the design of this Flatrack Fuel/ Water distribution system further and build an actual prototype for testing on the MK18A1.

5.0 CONCLUSION

The study performed at DDL OMNI analyzed whether it was feasible to take the capabilities of three RBU's (MK15, MK16, and MK17) and mount them on a flatrack that could be picked up by the MK18A1. This would eliminate four dedicated RBU's (if one considers replacing the MK14 with the MK18A1 and a flatrack), while allowing the flexibility of one vehicle performing all of the LVS capabilities. We also performed an analysis to determine the feasibility of using bulk liquid (fuel/water) flatracks to replace the current SIXCON tank and pump modules. The current system has a serious deficiency in delivering large quantities of bulk liquids.

The RBU analysis indicated that the MK17 is the most feasible candidate for replacement using a flatrack design due mainly to the simplicity of the current dedicated RBU. The MK17 analysis indicated a possible problem with vehicle stability due to the rise in height of the cargo bed and crane when using a flatrack. The analysis showed that the MK15 Wrecker/Recovery and the MK16 Fifth Wheel Semi-trailer Adapter are not good candidates for replacement using a flatrack design. The MK15 analysis indicated that the forces encountered by lifting and towing vehicles weighing up to 45 tons would cause problems at the flatrack attachment points. The MK16 analysis showed that major modifications would be needed to the flatrack to incorporate the fixed height location for the 5th wheel. Upon examining cost data to convert the three RBU's being analyzed to flatrack designs as compared to the current dedicated RBU's it indicated a cost increase for all three whether it was feasible or not.

DDL OMNI's bulk fuel/water analysis indicated that from a design point of view that both the dedicated fuel/water RBU and flatrack mounted fuel/water tank are feasible. Our study showed that given an offroad payload of 22.5 tons for the LVSR, fuel and water tanks in the 5000 gallon range are feasible.

The information gathered from this study is just a starting point. The next step in this analysis is to build and test prototypes to determine overall feasibility and if the capabilities meet the Marine Corps requirements for transportation units supporting MAGTF forces ashore operating in the littorals.

APPENDIX A. T-50 Underlift System Brochure

CHALLENGER™

Picture shows 6807 T-50 with two extra tool compartments and other popular challenger option.

Our heavy-duty towing and recovery vehicles continually outshine our competitors' models. Each heavy-duty Challenger unit provides the reach and capacity needed for tough recovery jobs — but strength isn't our only attribute. Our sleek body design and our many unique, popular towing and recovery options combine to make Challenger the undisputed leader in heavy-duty towing and recovery.

CHALLENGER™

Heavy Duty Series

Standard Equipment

- Fenderettes
- Safety holding valves on all cylinders
- Hydraulic rear jack legs with multi-position spades
- Twin hydraulic pumps
- Power boom elevation
- Dual outboard side-by-side elevation cylinders
- Single stage power extension
- Lubrication fittings on all moving parts
- 94" wide body with flat floor and wraparound canted tailgate
- 15" sill channels
- Dual control stations recessed at rear
- Mud flaps
- Federal standard 108 light group
- Wiring harness in conduit
- Provision for truck bar
- Vernier throttle control
- Four 12 cu. ft. tool compartments with shelves and stainless steel locking slam latches
- Safety chains
- Rear mounted recovery anchors

Optional Equipment

- Air clutch release on winches
- Rear mounted drag winch
- Tool compartment lighting
- Chrome handrails and boarding steps
- Formed steel light bar pylon
- Light bar
- Cable tensioners
- Switch panels
- Air shift PTO
- Cable wings
- Aluminum package
- Work lights
- Snatch blocks
- Additional tool compartments
- Door closures
- Rear mounted air and seven-way plug

Wrecker Specifications

	5802	6801	6807	8807	9907
Boom					
Basic structural rating retracted	40,000 lbs.	70,000 lbs.	70,000 lbs.	100,000 lbs.	120,000 lbs.
extended	12,000 lbs.	24,000 lbs.	20,000 lbs.	34,000 lbs.	50,000 lbs.
Reach past tailgate retracted	2"	- 4 3/4"	24"	24"	24 "
extended	67 1/2"	78 3/4"	180"	180"	180"
Range of elevation	0° - 50°	0° - 57°	0° - 50°	0° - 50°	0° - 50°
Winch					
Type	worm gear	worm gear	worm gear	worm gear	planetary
Capacity per winch	20,000 lbs.	25,000 lbs.	30,000 lbs.	45,000 lbs.	60,000 lbs.
Cable size	9/16" x 200'	5/8" x 200'	5/8" x 200'	3/4" x 250'	7/8" x 250'
Line configuration	dual	dual	dual	dual	dual
Chassis Recommendations					
GVW	27,500 lbs	40,000 lbs.	52,000 lbs.	60,000 lbs.	72,000 lbs.
R.B.M.(in./lb.) (each rail)	2,000,000*	2,500,000	3,500,000	3,500,000	4,000,000

Optional Underlift Specs	**T-12T** with 5802 only	**T-25**	**T-50**
Lift capacity (lbs.) retracted	12,000	25,000	50,000
extended	10,000	13,000	16,000
Tow capacity	50,000	80,000	84,000
Extended reach past tailboard	85"	85"	114"
Tilt	independent	independent	independent
degrees above	10°	15°	15°
below	10°	10°	10°

General information A tandem axle chassis is recommended (the 5802 may also use a single); consult factory for more information. Minimum frame length behind center line of rear axle is 45". The outside frame rails of chassis extending behind cab must be free of fuel and air tanks, battery boxes, etc. ***Warning:*** Do not exceed the boom or winch rating when hoisting or recovering. Do not exceed recommended working strength of cable (consult factory) when planning your cable rigging. Use snatch blocks and multiple lines to keep normal loads on cable.
* With tandem axle. 1,000,000 in./lb. with single axle.

• Specifications subject to change without notice.

CHALLENGER™

Challenger Representative:

miller INDUSTRIES
TOWING EQUIPMENT INC.
8503 Hilltop Drive
P.O. Box 120, Ooltewah, TN 37363
Phone: (423) 238-4171 1-800-292-0330
FAX: (423) 238-5371

10M-0596

APPENDIX B. BULK WATER and FUEL TANK SIZES

LVS-R
Fuel/Water Tank

	density(lb/ft^3	lb/gal
water	62.43	8.2
fuel	50.86	6.8

Weight	(lbs)
MHE Arm	3000
Pump	600

Payload/Tare
2.26

					Capacity (gal)			Weights			
					Gross	95%	80%	Gross(lbs)	Gross(tons)	Tare (lbs)	Payload (lbs)
W	OSHKOSH Data ----->				3000	2850	2400	29434	14.72	9034	20400
	L (ft)	W (ft)	H (ft)	V (ft^3)							
WATER	20	8	8.00	1280	9745	9258	7796	115269	57.63	35359	79910
	14	8	2.48	278	2115	2009	1692	25013	12.51	7673	17341
	14	8	3.27	366	2788	2649	2231	32981	16.49	10117	22864
	15	8	4.16	499	3801	3611	3040	44955	22.48	13790	31165
FUEL	20	8	8.00	1280	9574	9095	7659	93906	46.95	28806	65101
	14	8	3.04	340	2547	2419	2037	24979	12.49	7662	17317
	15	8	3.75	450	3366	3197	2693	33014	16.51	10127	22887
	16	8	4.79	613	4586	4356	3669	44981	22.49	13798	31183

10/8/97

LVS-R
Fuel/Water Tank

	density(lb/ft^3	lb/gal
water	62.43	8.2
fuel	50.86	6.8

Weight	(lbs)
MHE Arm	3000
Pump	600

Payload/Tare
3

OSHKOSH Data ----->

					Capacity (gal)			Weights			
					Gross	95%	80%	Gross(lbs)	Gross(tons)	Tare (lbs)	Payload (lbs)
WATER					3000	2850	2400	29434	14.72	9034	20400
	L (ft)	W (ft)	H (ft)	V (ft^3)							
	20	8	8.00	1280	9745	9258	7796	106547	53.27	26637	79910
	15	8	2.50	300	2284	2170	1827	24972	12.49	6243	18729
	15	8	3.30	396	3015	2864	2412	32963	16.48	8241	24722
	16	8	4.22	540	4112	3907	3290	44963	22.48	11241	33722
FUEL	20	8	8.00	1280	9574	9095	7659	86801	43.40	21700	65101
	15	8	3.07	368	2755	2618	2204	24982	12.49	6246	18737
	15	8	4.05	486	3635	3453	2908	32957	16.48	8239	24718
	16	8	5.19	664	4969	4720	3975	45050	22.52	11262	33787

10/8/97

LVS-R
Fuel/Water Tank

	density(lb/ft^3	lb/gal
water	62.43	8.2
fuel	50.86	6.8

Weight	(lbs)
MHE Arm	3000
Pump	600

Payload/Tare: 4

OSHKOSH Data - - - - - >

	L (ft)	W (ft)	H (ft)	V (ft^3)	Capacity (gal) Gross	95%	80%	Weights Gross(lbs)	Gross(tons)	Tare (lbs)	Payload (lbs)
WATER					3000	2850	2400	29434	14.72	9034	20400
	20	8	8.00	1280	9745	9258	7796	99888	49.94	19978	79910
	13	8	3.08	320	2439	2317	1951	24997	12.50	4999	19998
	15	8	3.52	422	3216	3055	2573	32963	16.48	6593	26370
	16	8	4.51	577	4395	4175	3516	45049	22.52	9010	36040
FUEL	20	8	8.00	1280	9574	9095	7659	81376	40.69	16275	65101
	15	8	3.28	394	2944	2797	2355	25023	12.51	5005	20018
	16	8	4.06	520	3887	3693	3110	33039	16.52	6608	26431
	16	8	5.53	708	5294	5030	4235	45001	22.50	9000	36001

LVS-R

Fuel/Water Tank

	density(lb/ft^3	lb/gal
water	62.43	8.2
fuel	50.86	6.8

Weight	(lbs)
MHE Arm	3000
Pump	600

Payload/Tare
5

	L (ft)	W (ft)	H (ft)	V (ft^3)	Capacity (gal) Gross	95%	80%	Weights Gross(lbs)	Gross(tons)	Tare (lbs)	Payload (lbs)
WATER	OSHKOSH Data - - - - - >				3000	2850	2400	29434	14.72	9034	20400
	20	8	8.00	1280	9745	9258	7796	95892	47.95	15982	79910
	13	8	3.21	334	2542	2415	2033	25010	12.50	4168	20842
	16	8	3.44	440	3352	3185	2682	32987	16.49	5498	27489
	16	8	4.69	600	4570	4342	3656	44974	22.49	7496	37478
FUEL	20	8	8.00	1280	9574	9095	7659	78121	39.06	13020	65101
	16	8	3.20	410	3064	2910	2451	24999	12.50	4166	20832
	16	8	4.22	540	4040	3838	3232	32967	16.48	5495	27473
	16	8	5.76	737	5514	5239	4412	44998	22.50	7500	37498

LVS-R
Fuel/Water Tank

	density(lb/ft^3	lb/gal
water	62.43	8.2
fuel	50.86	6.8

Weight	(lbs)
MHE Arm	3000
Pump	600

Payload/Tare
6

	L (ft)	W (ft)	H (ft)	V (ft^3)	Capacity (gal) Gross	95%	80%	Weights Gross(lbs)	Gross(tons)	Tare (lbs)	Payload (lbs)
WATER	OSHKOSH Data ----->				3000	2850	2400	29434	14.72	9034	20400
	20	8	8.00	1280	9745	9258	7796	93229	46.61	13318	79910
	14	8	3.07	344	2618	2487	2094	25044	12.52	3578	21466
	15	8	3.77	452	3444	3272	2755	32951	16.48	4707	28243
	16	8	4.83	618	4707	4472	3766	45030	22.51	6433	38597
FUEL	20	8	8.00	1280	9574	9095	7659	75951	37.98	10850	65101
	16	8	3.29	421	3150	2992	2520	24988	12.49	3570	21418
	16	8	4.34	556	4155	3947	3324	32963	16.48	4709	28254
	16	8	5.92	758	5668	5384	4534	44963	22.48	6423	38540

10/8/97

LVS-R
Fuel/Water Tank

	density(lb/ft^3	lb/gal
water	62.43	8.2
fuel	50.86	6.8

Weight	(lbs)
MHE Arm	3000
Pump	600

Payload/Tare
2.26

					Capacity (gal)			Weights			
					Gross	95%	80%	Gross(lbs)	Gross(tons)	Tare (lbs)	Payload (lbs)
W	OSHKOSH Data - - - - - >				3000	2850	2400	29434	14.72	9034	20400
A											
T	L (ft)	W (ft)	H (ft)	V (ft^3)							
E	20	8	8.00	1280	9745	9258	7796	112269	56.13	32359	79910
R											
	12	8	3.24	311	2368	2250	1894	25010	12.51	5592	19418
	14	8	3.57	400	3044	2892	2435	33007	16.50	8045	24962
	16	8	4.16	532	4054	3851	3243	44952	22.48	11709	33243
F	20	8	8.00	1280	9574	9095	7659	90906	45.45	25806	65101
U											
E	14	8	3.41	382	2857	2714	2285	25019	12.51	5595	19424
L	15	8	4.09	491	3671	3487	2937	33007	16.50	8045	24962
	16	8	5.11	654	4892	4648	3914	44986	22.49	11720	33267

10/8/97

LVS-R
Fuel/Water Tank

	density(lb/ft^3	lb/gal
water	62.43	8.2
fuel	50.86	6.8

Weight	(lbs)
MHE Arm	3000
Pump	600

Payload/Tare
3

					Capacity (gal)			Weights			
					Gross	95%	80%	Gross(lbs)	Gross(tons)	Tare (lbs)	Payload (lbs)
	OSHKOSH Data - - - - - >				3000	2850	2400	29434	14.72	9034	20400
	L (ft)	W (ft)	H (ft)	V (ft^3)							
WATER	20	8	8.00	1280	9745	9258	7796	103547	51.77	23637	79910
	14	8	3.00	336	2558	2430	2046	24969	12.48	3992	20976
	16	8	3.38	433	3294	3129	2635	33013	16.51	6003	27010
	16	8	4.50	576	4385	4166	3508	44946	22.47	8987	35960
FUEL	20	8	8.00	1280	9574	9095	7659	83801	41.90	18700	65101
	16	8	3.22	412	3083	2929	2466	24950	12.47	3987	20962
	16	8	4.14	530	3963	3765	3171	32936	16.47	5984	26952
	16	8	5.53	708	5294	5030	4235	45001	22.50	9000	36001

LVS-R
Fuel/Water Tank

	density(lb/ft^3	lb/gal
water	62.43	8.2
fuel	50.86	6.8

Weight	(lbs)
MHE Arm	3000
Pump	600

Payload/Tare
4

					Capacity (gal)			Weights			
					Gross	95%	80%	Gross(lbs)	Gross(tons)	Tare (lbs)	Payload (lbs)
WATER	OSHKOSH Data - - - - - >				3000	2850	2400	29434	14.72	9034	20400
	L (ft)	W (ft)	H (ft)	V (ft^3)							
	20	8	8.00	1280	9745	9258	7796	96888	48.44	16978	79910
	14	8	3.20	358	2729	2592	2183	24969	12.48	2594	22375
	16	8	3.60	461	3508	3333	2807	32960	16.48	4192	28768
	16	8	4.81	616	4687	4453	3750	45046	22.52	6609	38437
FUEL	20	8	8.00	1280	9574	9095	7659	78376	39.19	13275	65101
	15	8	3.67	440	3294	3129	2635	24998	12.50	2600	22399
	16	8	4.42	566	4232	4020	3385	32968	16.48	4194	28775
	17	8	5.55	755	5645	5363	4516	44986	22.49	6597	38389

LVS-R
Fuel/Water Tank

	density(lb/ft^3	lb/gal
water	62.43	8.2
fuel	50.86	6.8

Weight	(lbs)
MHE Arm	3000
Pump	600

Payload/Tare
5

	L (ft)	W (ft)	H (ft)	V (ft^3)	Capacity (gal) Gross	95%	80%	Weights Gross(lbs)	Gross(tons)	Tare (lbs)	Payload (lbs)
WATER	OSHKOSH Data - - - - - >				3000	2850	2400	29434	14.72	9034	20400
	20	8	8.00	1280	9745	9258	7796	92892	46.45	12982	79910
	14	8	3.34	374	2848	2706	2278	25025	12.51	1671	23354
	16	8	3.75	480	3654	3472	2924	32960	16.48	2993	29966
	16	8	5.00	640	4873	4629	3898	44946	22.47	4991	39955
FUEL	20	8	8.00	1280	9574	9095	7659	75121	37.56	10020	65101
	16	8	3.58	458	3427	3256	2742	24967	12.48	1661	23306
	16	8	4.61	590	4413	4193	3531	33014	16.51	3002	30011
	17	8	5.78	786	5879	5585	4704	44976	22.49	4996	39980

10/8/97

LVS-R

Fuel/Water Tank

	density(lb/ft^3	lb/gal
water	62.43	8.2
fuel	50.86	6.8

Weight	(lbs)
MHE Arm	3000
Pump	600

Payload/Tare
6

					Capacity (gal)			Weights			
					Gross	95%	80%	Gross(lbs)	Gross(tons)	Tare (lbs)	Payload (lbs)
W	OSHKOSH Data ----->				3000	2850	2400	29434	14.72	9034	20400
A											
T	L (ft)	W (ft)	H (ft)	V (ft^3)							
E	20	8	8.00	1280	9745	9258	7796	90229	45.11	10318	79910
R											
	16	8	3.00	384	2924	2777	2339	24969	12.48	996	23973
	16	8	3.86	494	3762	3574	3009	32986	16.49	2141	30845
	17	8	4.85	660	5022	4771	4017	45042	22.52	3863	41179
F	20	8	8.00	1280	9574	9095	7659	72951	36.48	7850	65101
U											
E	16	8	3.69	472	3533	3356	2826	25026	12.51	1004	24022
L	16	8	4.74	607	4538	4311	3630	33001	16.50	2143	30858
	17	8	5.95	809	6052	5750	4842	45015	22.51	3859	41156

LVS-R
Tanker
(cylindrical, spherical ends)

	density(lb/ft^3	lb/gal	Pump weight (lbs)	Payload/Tare
water	62.43	8.2	750	5.34
fuel	50.86	6.8		

Hapag-Lloyd data
280 200 1

	L (ft) cntr. sect.	Tank H (ft)	L (ft) Total	V (ft^3)	Capacity (gal) Gross	Capacity (gal) 95%	Capacity (gal) 80%	Weights Gross(lbs)	Weights Gross(tons)	Weights Tare (lbs)	Weights Payload (lbs)
					5055	4800	4040	52910		8160	44750
WATER	13	6	19.00	480	3658	3475	2926	36359	18.18	5617	29993
	11.46	6	17.46	437	3326	3160	2661	33133	16.57	5108	27276
	7.63	6	13.63	329	2502	2377	2002	25111	12.56	3842	20518
FUEL	13	6	19.00	480	3593	3414	2875	29760	14.88	4576	24434
	10.27	6	16.27	403	3016	2865	2413	25101	12.55	3841	20510

10/8/97

LVS-R
Tanker
(rectangular)

	density(lb/ft^3)	lb/gal
water	62.43	8.2
fuel	50.86	6.8

Pump weight (lbs) 850

Payload/Tare 5.34

Hapag-Lloyd data
280 200 1

	L (ft)	W (ft)	H (ft)	V (ft^3)	Capacity (gal) Gross	95%	80%	Weights Gross(lbs)	Gross(tons)	Tare (lbs)	Payload (lbs)
					5055	4800	4040	52910		8160	44750
WATER	20	8	8.00	1280	9745	9258	7796	95725	47.86	14964	79910
	18	7.5	4.25	574	4368	4150	3495	43377	21.69	6708	35819
	17	8	2.40	326	2485	2361	1988	25043	12.52	3816	20377
	17	8	3.20	435	3313	3148	2651	33107	16.55	5088	27170
	17	8	4.40	598	4556	4328	3645	45204	22.60	6996	37358

	L (ft)	W (ft)	H (ft)								
FUEL	20	8	8.00	1280	9574	9095	7659	78142	39.07	12191	65101
	17	8	6.00	816	6103	5798	4883	50124	25.06	7772	41502
	17	8	2.95	401	3001	2851	2401	25076	12.54	3821	20405
	17	8	3.90	530	3967	3769	3174	32878	16.44	5052	26976
	17	8	5.40	734	5493	5218	4394	45196	22.60	6995	37352

LVS-R
Tanker
(rectangular)

	density(lb/ft^3)	lb/gal	Weights	(lbs)
water	62.43	8.2	Pump	850 Payload/Tare
fuel	50.86	6.8		5.34

	Hapag-Lloyd data 280 200 1				Capacity (gal)			Weights			
					Gross	95%	80%	Gross(lbs)	Gross(tons)	Tare (lbs)	Payload (lbs)
WATER					5055	4800	4040	52910		8160	44750
	L (ft)	W (ft)	H (ft)	V (ft^3)							
	20	8	8.00	1280	9745	9258	7796	95725	47.86	14964	79910
	17	8	2.40	326	2485	2361	1988	25043	12.52	3816	20377
	17	8	3.20	435	3313	3148	2651	33107	16.55	5088	27170
	17	8	4.40	598	4556	4328	3645	45204	22.60	6996	37358
FUEL	L (ft)	W (ft)	H (ft)								
	20	8	8.00	1280	9574	9095	7659	78142	39.07	12191	65101
	17	8	2.95	401	3001	2851	2401	25076	12.54	3821	20405
	17	8	3.90	530	3967	3769	3174	32878	16.44	5052	26976
	17	8	5.40	734	5493	5218	4394	45196	22.60	6995	37352